THE WORLD'S DEBT TO DARWIN.

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For centuries science has been engaged in glorifying the commonplace, in showing that natural phenomena are due to natural causes, and that the most stupendous as well as the most subtle phenomena, removed from us perhaps by almost an eternity of time and space, are but manifestations of continuous natural processes, which we may see and study for ourselves in the common phenomena of our daily lives. At every step in this progress science has had to contend with intrenched supernaturalism; in the beginning every happening, even the most trivial, was ascribed to some supernatural cause; to our ancestors it was self-evident that extraordinary occurrences required extraordinary causes, and that natural causes were wholly inadequate to accomplish great results. But step by step, before advancing knowledge of nature, supernaturalism retired from the plane of ordinary phenomena until she dwelt only in the misty mountain tops of origins, beginnings, creations; and day by day there was a growing respect for nature and her powers.

In this warfare of science with tradition there have been crises, turning points, no less important for mankind than any which are associated with the rise and fall of nations; such a crisis was reached when astronomy was emancipated from the thralldom of supernaturalism by Newton and Laplace; when geology was freed by Hutton and Lyell from the absurd cataclysmal theory, which virtually taught that age after age the creator, experimenting at world building, found the results not good, and so wiped them out and began again; but probably no similar crisis has had so profound an effect upon mankind as that revolution in our notions of the genesis of the living world which we associate preëminently with the name of Charles Darwin.

I.

Without doubt the greatest scientific generalization of the past century is the theory of organic evolution. The only other which can be compared with it, the doctrine of the conservation of energy, has not so profoundly influenced human life nor so greatly changed all the currents of human thought. Evolution has not only transformed biology, psychology, sociology, anthropology and geology, but it has given a new point of view to all science, art, and even religion. "The great theory of evolution," said John Fiske, "is rapidly causing us to modify our opinions on all subjects whatsoever."

Though many forerunners of this theory may be found in former centuries, its establishment upon a scientific basis belongs to the nineteenth century. How general the feeling is that evolution is the greatest scientific principle of modern times, and how almost universally its establishment is identified with a single man and a single book, is shown by the remarkable symposium which appeared in one of our magazines a few years ago.[1] Ten men, selected for their eminence in literature and education, were asked to give their opinions as to the most influential books of the nineteenth century. No one of these men was by training or profession a biologist, with the exception of one psychologist no one of them was especially identified with any natural science, and yet the only book of the century upon which all ten agreed was Darwin's "Origin of Species."

The doctrine of descent is so wholly in accord with the facts of biology, and indeed of all sciences; it is so reasonable and simple that one can scarcely believe that it had few adherents until after the middle of the last century. Yet the evolutionary speculations of the "Naturphilosophen," and even the more scientific hypotheses of Buffon, Lamarck and St. Hilaire in the first quarter of the century produced, on the whole, an unfavorable impression upon naturalists, and up to the year 1859 the problem of the origin of species, their relationships to one another, their geographical and geological distribution, was regarded as the "mystery of mysteries,"

[1] *Outlook*, December 1, 1900.

perhaps only solvable by the miracle of special and supernatural creation. Darwin wrote in his autobiography:

It has sometimes been said that the success of the "Origin" proved "that the subject was in the air," or "that men's minds were prepared for it." I do not think that this is strictly true, for I occasionally sounded not a few naturalists, and never happened to come across a single one who seemed to doubt about the permanence of species.

In 1844 he wrote to Hooker:

I have been now, ever since my return (from the voyage round the world), engaged in a very presumptious work, and I know not one individual who would not say a very foolish one. I was so struck with the distribution of the Galapagos organisms, etc., and with the character of the American mammifers, etc., that I determined to collect blindly every sort of fact which could bear in any way on what are called species. I have read heaps of agricultural and horticultural books and have never ceased collecting facts. At last gleams of light have come, and I am almost convinced (quite contrary to the opinion I started with) that species are not (it is like confessing a murder) immutable. Heaven forfend me from Lamarck's nonsense of a "tendency to progression," "adaptation through the slow willing of animals," etc.! But the conclusions I am led to are not widely different from his, though the means of change are wholly so. I think I have found out (here's presumption) the simple way in which species become exquisitely adapted to various ends. You will now groan and think to yourself, "on what a man I have been wasting my time and writing to." I should five years ago have thought so.

This single extract reveals the general opinions of naturalists on the subject of species before the publication of Darwin's work. We should never forget that in spite of all the theories and speculations on evolution which preceded Darwin it was still commonly believed before 1859 that species had arisen by supernatural creation, that the question of their origin was not therefore a scientific problem, but that it was the one great exception to the reign of natural causes in the natural world. It detracts nothing from Darwin's preëminent services to say that he was not the first to propose the doctrine of the evolution of species. What is much more important is that he was the first to establish it; he brought a dead speculation to life and gave it scientific standing, so that it is now accepted by practically everybody, and in all justice the credit of this greatest intellectual achievement of the past century belongs to him. The world-wide difference between Darwin and his pre-

decessors lay in the simple but all-important matter of evidence. They had proposed more or less possible and more or less reasonable hypotheses, but these failed of general acceptance for lack of evidence. Darwin brought to bear on the problem his great power and range of observation; he collected in his books such vast stores of facts bearing on his problem, that they are today the wonder and admiration of scholars; in masterly manner he coördinated the scattered and diverse evidence drawn from botany, zoölogy, morphology, physiology, embryology, ecology, palæontology, geology, agriculture, horticulture and animal breeding, and he presented the evidence with such force of logic, such clearness of exposition, such judicial candor, that he finally and forever overthrew the dogma of immutability of species and their special creation, and established in its place the doctrine of evolution.

The effect and influence of this work can scarcely be overestimated. Once Darwin had rendered acceptable to naturalists the doctrine of organic descent with modifications, it was found that it gave new meaning to the whole science of biology. Like a magic formula it solved the age-long problems of classification, affinity, good and bad species, aberrant and synthetic types; by it the mysteries of geographical and geological distribution were explained; by its guidance the records of the ancient world, as preserved in the rocks, were deciphered and correlated and missing links between many great groups of organisms found; in its light the history of the development of the individual from the egg acquired new significance. Physiology and psychology, no less than morphology, have felt its transforming touch, and not least among its results have been its revelations as to the nature, origin and relationships of man.

These stupendous results do not represent merely the frenzy of a new enthusiasm. There have been, of course, assertions which outran evidence, and skepticism which denied all evidence, but in spite of these excesses every year since 1859 has contributed in ever increasing measure to the more complete establishment of the doctrine of descent and to the wider extension of this theory into every field of human thought and endeavor.

The world's greatest debt to Darwin is for the work which he

did in establishing the theory of organic evolution, and this year marks not only the centenary of the birth of Darwin, but also the semicentennial of the publication of his greatest book, the "Origin of Species," which did more to establish that theory than any other book ever published. But it should not be forgotten that the world is indebted to him for much besides this. Darwin was one of the last of the great naturalists. He was the most painstaking and accurate observer and experimenter and he contributed largely to knowledge in several branches of science. He was a geologist of note and his works on volcanic islands and on the origin of coral islands alone would have given him a high place among geologists. He was a distinguished botanist and his studies on the fertilization of orchids, cross and self fertilization in the vegetable kingdom, insectivorous plants, climbing plants and the power of movement in plants, laid broad and deep the foundations for the study of physiological processes. He was a great zoölogist, as his volumes on the zoölogy of the expedition of the "Beagle," on recent and fossil Cirripedia, on the activities of earthworms, and on the variations of animals and plants, testify. His work on the "Descent of Man" shows the value of his contributions to the science of anthropology, and I have been told by psychologists that his volume on the "Expression of the Emotions" is one of the best and most fundamental of all works on this subject. Altogether he published twenty-two books (thirty-three, counting second and subsequent editions) and eighty-two papers and contributions. These statements indicate how broad was his mind, and how much of fact he contributed to science.

II.

Undoubtedly Darwin's most distinctive and important contribution to organic evolution is his theory of natural selection, or what has been generously, but unfortunately named "Darwinism." Although this was the chief corner stone in Darwin's evolutionary philosophy, it was not the only stone in that structure, as is the case with some of his followers. Darwin was broader than "Darwinism." He recognized more than this one factor of evolution, though he always believed natural selection to be the chief one.

I need not repeat here how Darwin was led to adopt this theory; how he found that selection on the part of the breeder was the factor which determined the course of transformation in domestic animals and plants; how, in his search for a similar factor in nature, the essay of Malthus on population suggested to him the elimination of the unfit and the preservation of favored races in the struggle for life; how for twenty years he had been developing this idea, when he received from Wallace, then in the Malay Archipelago, an essay on the same subject, and how this essay together with Darwin's sketch of his theory were presented simultaneously to the Linnæan Society on July 1, 1858—all this is now familiar history. It may not be so well known that at the semicentennial of the publication of these essays, held last July, Wallace, who was present, said that he had been given much more than his due in being called the codiscoverer with Darwin of natural selection, and that his share in the discovery should be proportional to the length of time which each had devoted to the subject, *i. e.,* about as one week is to twenty years.

Probably no scientific theory has been so widely and so fully discussed as has natural selection. On the one hand were those who, like Wallace and Weismann, maintained that it was the only and the all-sufficient factor of organic evolution; on the other hand were many who either denied that it was any factor at all, or who ascribed to it only a minor rôle. It was the ill fortune of the theory to have aroused profound theological opposition, which gave to the discussion an intense controversial aspect and which prevented a calm and unprejudiced judgment of the theory. Furthermore, the character of the theory itself invited discussion. It was based upon principles so general and familiar that everyone felt free and competent to discuss it, and as it was difficult to subject it to demonstrative proof it freed biologists as well as laymen from such uncomfortable restraints, and left much room for mere inference and speculation. Scientific principles are not established by dialectics and while this whole discussion has been immensely educative, it is doubtful whether its scientific results have been commensurate with the time and effort it has consumed. It is probable that the intense antagonism to the theory, chiefly on the part of men who were not

scientists, led to the exaggeration of the evidence for it and the minimizing of the difficulties to be explained. Certain it is that there has been much dogmatism on the subject, an over-confidence in certain hypotheses, and a general lack of scientific caution, which has led biology astray in some instances and has caused persons who are not biologists to accept insecure hypotheses as foundations for more elaborate specualtions; this is especially true in the fields of sociology and psychology. Dogmatism always begets skepticism and we need not be surprised to find that in recent times a few biologists have totally rejected natural selection as a factor of evolution. But I think we may be surprised at the intensity of feeling and the wholly intemperate attacks of some of the younger biologists upon this theory, and especially is this true in view of the fact that Darwin himself always avoided controversy and was one of the kindest and gentlest of men. Unfortunately the lack of judicial calm is quite as noticeable in these later attacks as in the earlier and less scientific ones.

Dennert says:

> Darwinism belongs to the past, we are standing at its death bed, and its friends are preparing to give it a decent burial.

Driesch also, with more scientific authority, but with no less spleen, says:

> Darwinism now belongs to history; like that other curiosity of our century, the Hegelian philosophy; both are variations on the theme: how one manages to lead a whole generation by the nose.

He calls it a new kind of religion, which would have done honor to Mohammed, and speaks of the softening of the brain of Darwinians. More recently, however, when Driesch addressed an English-speaking audience at Aberdeen, he was much more dignified and conciliatory and said, "Certainly natural selection is a *vera causa*" but he argues that it is a negative, an eliminating factor, and not a creative one.

It is surprising how persistent is the misunderstanding of natural selection, which is implied in this statement. The term "natural selection" was chosen, as Darwin says, because of its supposed resemblance to artificial selection, but it was so frequently misunderstood that he would have liked, if possible to have changed it to

"natural elimination," but he fondly hoped that in time everyone would come to understand it. Over and over again he recognized that natural selection was a negative, an eliminating factor. He never held that it was anything more than a sieve, as De Vries puts it, to sort out favorable from unfavorble variations.

The only difference of opinion between Darwinians and anti-Darwinians at present is a purely quantitative one as to the amount of value to be assigned to natural selection. It is perfectly evident that organisms which cannot live must die, and that those which are severely handicapped must, on the whole, perish sooner than those which are not so handicapped. No naturalist will question the fact that many ill-adapted forms are eliminated before they can leave offspring. The real question at issue is whether this elimination is severe enough to weed out all but the most favorable variations, as Darwinians generally assume, or whether it weeds out only the least favorable variations, as anti-Darwinians claim. If variations occur in all directions, as Darwin believed, natural selection must eliminate more than half of these in order to be a truly directive factor in evolution; and the less severe the elimination is the less directive is this factor. This may be illustrated by a diagram of a radiating figure in which the center of the figure represents the norm of a species from which lines, representing variations, proceed in all directions. If natural selection, or elimination, be represented by portions of a circle inclosing this figure and blocking the radii, then one quarter of the circle will block approximately one quarter of the radii; a semicircle, one half of the radii; three quarters of the circle, three quarters of the radii; and in general the more completely the circle (natural selection) blocks the radii (variations) the more directive it becomes. Many recent studies indicate that the elimination due to natural selection is not so extensive as Darwin and his followers believed, and that therefore it is not so important a factor in directing the course of evolution as they supposed. That Darwin himself was much impressed by some such consideration is shown by the statement made in his later works that he thought the most serious mistake which he had made was in attributing too much influence to natural selection, and too little to the inherited effects of environment and of use and disuse upon organisms.

Natural selection, or "Darwinism," is usually spoken of as if it were the only factor of evolution which Darwin recognized. As a matter of fact only three chapters of the "Origin of Species" were devoted primarily to this subject, whereas three were devoted to variation and its laws, and his great work on the "Variations of Animals and Plants," which he omitted from the "Origin" merely to make the latter a shorter and more readable account, occupies two large volumes. It is particularly unjust and untrue to say that Darwin's theory of evolution recognized only the negative factor of elimination. In reading the criticisms of Darwin's theory one cannot fail to be impressed with the fact that many of the critics do not know Darwin's works. Let us hope that one of the results of the Darwin anniversaries which are being held this year throughout the civilized world will be to induce people generally, and the critics in particular, to read and re-read Darwin's books.

I confess that every time I look into his books it is with some new feeling of surprise and admiration. How thoroughly modern they are in most things! Apparently they might have been written after the promulgation of Neo-Lamarckism, Neo-Darwinism, mutation, orthogenesis and other modern theories, and one feels inclined again and again to look critically at the date of the book. It is an interesting fact that most of the objections which have been advanced in recent years to the Darwinian factors, were considered at length by Darwin in later editions of the "Origin," and it is amusing to read these modern objections and then find the answers to them given by Darwin himself in calm, judicial and convincing manner. One who knows Darwin's works can understand and in a measure sympathize with the enthusiasm of Emerson for Plato, when he said, "In Plato are all things, whether written or thought."

The positive side of Darwin's theory, and indeed of every other theory of evolution, is the variability of organisms, and the principal question which confronted him, as it confronts every evolutionist today, was this—"What is the nature and what are the causes of variation?" Darwin devoted many years of intense labor to the study of this problem and in his many volumes he brought together a larger amount of information on this subject than has ever been collected by any one man before or since. He concluded that the

causes of variation are in the main these: (1) The influence of the environment and of changed conditions of life (2), the effects of the use and disuse of parts, (3) the organic correlation of one variation with another so that the two necessarily arise together. Again and again he asserts as one of his principal conclusions, which he makes especially emphatic by placing it at the head of certain chapters, that "variability of every kind is due to changed conditions of life." He considered the value of sports, or what De Vries calls "mutations," in the production of new races, and he decided that their value was not usually very great. He considered the question as to whether variations occur in every direction, or principally in one, whether they are multifarous or unifarous, and he concluded on the whole that the evidence was chiefly favorable to the former view.

It is in these three directions that our knowledge of the origin of variations has made the greatest advance within recent years, viz., (1) The effects of the conditions of life in producing new races, (2) the value of sudden sports or mutations, (3) the question whether variations are fluctuating or definitely directed. All of these factors were considered by Darwin and to the first he assigned great importance; and if the evidences now to be had show that the second and third factors named are more important than he supposed, they do not fundamentally nor seriously change his theory. In some quarters there is a tendency to hail the mutation theory of De Vries and the orthogenesis theory of Eimer and Whitman as antagonistic to the Darwinian theory, but there is absolutely no reason why all of these factors may not coexist harmoniously. Both De Vries and Whitman hold that natural selection is a factor, and an important one, in the evolution of organisms, and if the theories of mutations or orthogenesis shall prove to be well founded, the whole problem of evolution will be immensely simplified and the greatest objections to the Darwinian theory will disappear, viz., (1) The lack of sufficient time for evolution, (2) the paleontological evidence that evolution has been in directed lines, (3) the inutility of many specific characters, (4) the complete disappearance of many rudimentary organs, (5) the harmonious coadaptation of parts.

III.

Darwin's theory of evolution includes much more than the doctrine of descent; it attempts to explain by natural causes the wonderful and exquisite adaptations of organisms to their conditions of life. The deepest and most mysterious problems of biology do not center in the structure of organisms, nor in their functions, nor even in their oigin, but in their fitness. Everywhere the universe is a cosmos and not a chaos; "Order is heaven's first law;" but this order is especially evident in the organic world. The subject of organic adaptations is undoubtedly a dangerous one for the scientist, full of pitfalls for the unwary and with many alluring calls to metaphysical speculation, but it is a subject which lies in the background of every biological problem. "Life is," as Professor Brooks taught, "response to the order of nature," and it is the element of useful, apparently purposive, response, which more than anything else distinguishes the living from the lifeless, and separates the methods of biology from those of chemistry and physics. Indeed Herbert Spencer defined life as "continuous adjustment of internal relations to external relations"; lack of such adjustment invariably leading to death.

One cannot speak of any organ or tissue of an animal or plant without illustrating such adjustment. Consider the fitness of the skeleton for support, of the muscles for contraction, of the alimentary system for digestion and absorption, of the heart with its valves for pumping and the blood vessels for circulating blood. Consider the truly remarkable contrivances for insuring cross-fertilization in animals and plants and for the protection and nourishment of the young. Consider the fitness of the nervous system for receiving and transmitting stimuli; the fitness of the eye for seeing, of the ear for hearing, of the tongue for tasting. Think of the fitness of every organ for its particular use, and then consider the peculiar fitness with which these organs are coördinated into an harmonious whole. Viewed in this light, "What a piece of work is man," or any other organism!

Such adaptations to general conditions of existence are so common that to most persons they do not seem remarkable, while some peculiar adaptation, such as the leaf insect, or the Venus fly-trap,

seems wonderful simply because it is not common. Many of these more uncommon adaptations have played an important part in the discussions of the various theories of evolution which have been advanced during the past century. As illustrations of adaptations to particular conditions of life may be mentioned the fitness of horses' limbs for running, those of seals for swimming, those of birds for flight. Innumerable adaptations are found, also, among animals and plants, for offense and defense, such as the sting of the bee, the poison of serpents, the tusks, horns and armor of many animals, the well-known structures and habits of the porcupine, the rattlesnake, the opossum and the skunk. Again many animals, such as the stick insect and the dead-leaf butterfly, are so like the objects upon which they are commonly found that it is difficult to detect them even when searching for them.

The ability which many eggs, embryos and adults have of restoring lost parts, and in general of resuming the typical form after injury constitutes another class of fitness which is of the greatest interest. Most remarkable also are the adaptations which certain organisms show to desiccation, to extremes of temperature and to various poisons. In particular the adaptations of organisms to bacterial poisons and to snake venom, where every kind of poison leads to the formation of a particular kind of anti-body which counteracts the poison, are among the most surprising known.

The list of such fitnesses it well-nigh endless and the question of their origin forms one of the most striking and fundamental problems of biology. How have lowly organisms learned to utilize processes of chemistry and physics so subtle that intelligent man only after centuries of civilization has come only to the place where he can appreciate these processes but cannot duplicate them?

Innumerable attempts have been made both by philosophers and biologists to find a natural explanation of this fundamental phenomenon of life. One need only enumerate the "perfecting principle" of Aristotle, the "active teleological principle" of Kant, Lamarckism, Darwinism, several kinds of selection, and finally the "entelechy" of Driesch to indicate over what a field these explanations have ranged.

If for the present we disregard those views which really attempt

no causal explanation, but merely restate the mystery in terms of perfecting principles or entelechies, and those which find the causes of adaptations in unknown laws of variation, there remain two attempted explanations of organic fitness which may be known by the general terms of Lamarckism and Darwinism. Lamarckism is a theory which attempts to explain racial adaptations as the result of the inheritance of individual, acquired adaptations. It is well known that extrinsic and intrinsic changes frequently produce adaptive modifications in organisms, and Lamarckism maintains that these individual, somatic modifications are ultimately inherited and that in this way adaptations, characteristic of a race or species, arise. Thus all inherent or germinal adaptations are supposed to be derived from acquired or somatic ones. How these individual somatic adaptations arise in the first place Lamarckism does not undertake to explain; the adaptive character of the response of an organism to its environment, to use and disuse, and to its needs, remains as much of a mystery as ever. As we know Darwin believed that some individual adaptations, especially those which resulted from the use or disuse of parts, might be inherited and thus become racial or specific. This theory if true would afford a good explanation of inherited adaptedness; unfortunately there is no evidence that such acquired adaptations are regularly inherited. For years this evidence has been earnestly sought but no such confirmations have been found as would certainly have been the case if this kind of inheritance were at all common.

Modern Darwinism, on the other hand, rejects the possibility of the inheritance of such acquired adaptations, and maintains that there is no genetic connection between acquired and inherent fitness. It maintains that all adaptations are due to multifarous variations among offspring and the elimination by natural selection of those which are poorly adapted. All adaptations which are for the good of the species rather than of the individual, admit of no other natural explanation; such adaptations could not have arisen from adaptations acquired by an individual as Lamarckians assume, since they benefit the species at the expense of the individual. Darwin showed in masterly manner that the continual elimination of the unfit and the preservation of favored races would gradually improve the stan-

dard of fitness until such exquisite adaptations as are found, for example, in the case of the eye might be reached; many persons now doubt the omnipotence of selection, but if to natural selection there be added some such factors as orthogenesis or mutations most of the inherited adaptedness of animals and plants may be so explained. This seems to me to be the crowning feature of Darwin's great theory; it is not so much its species-forming power which impresses me as its ability to explain on simple and natural principles very many of the wonderful adaptations of the living world.

On the other hand it must be admitted that there is one entire class of adaptations which natural selection, as held by Darwin, is unable to explain. Neither Darwinism, Lamarckism, nor any other mechanical explanation hitherto proposed is able to explain satisfactorily all the equally wonderful acquired, individual, or somatic adaptations of organisms. All scientific theories of evolution hold that racial adaptations are due to experience; Lamarkism, that they are the directly inherited effects of individual experience; Darwinism, that they are the indirect results of experience, through the presentation of many variants to the action of selection and the survival of the best adapted. Neither of these theories could explain sudden adaptations to conditions never experienced before; and yet some individual adaptations are apparently of this sort. Bear with me while I mention some of these cases which have been held by several recent writers to be fatal to Darwinism. It has been found that if the lens of the eye of a newt is removed it will be regenerated perfectly within a few weeks. Now it may be assumed that such an injury as this, involving as it does a very delicate surgical operation, never took place in nature, and yet pure Darwinism can explain this regeneration only by the supposition that the loss of the lens has taken place so frequently among the ancestors of present newts that they are perfectly adapted to this injury. Again the eggs, embryos or adults of many animals may be cut or broken into fragments or otherwise injured in such ways as could never have occurred in nature, and yet these fragments will in many cases give rise to perfect animals, "as if the pattern of the whole existed in every part." This power of regeneration cannot be the result of past experience, since there is no constant relation between it and

liability to injury. Other contingent, individual adaptations of a still more striking kind are found in the acclimatization of organisms to certain poisons, particularly bacterial poisons and snake venom. It has been shown that, as an antidote to these toxins, various anti-toxins are formed, and for every toxin, or at least for every tox-albumen its own particular anti-body. Now many of these poisons are of such a sort that it is perfectly certain that the immediate ancestors of the forms poisoned could never have experienced them, and yet the response is as perfect as it could be if it had been due to long experience. Many other similar cases might be cited if time allowed, but these are enough. The apparently intelligent and purposive response of an organism to a stimulus or environment which it has never experienced before is one of the most mysterious and fundamental problems of biology.

There are, therefore, adaptations which neither Lamarckism nor Darwinism nor any other system so far proposed can explain satisfactorily, and this has led several biologists, notably Wolff and Driesch, to the conclusion that these theories "fail all along the line." But this conclusion appears to me hasty and extreme. There are many adaptations, as we have seen, which may be beautifully explained by the Darwinian theory, viz., all racial or inherent adaptations which are not first called forth by the contingent stimulus to which they are the appropriate and useful response. On the other hand adaptations of the latter sort are problems of physiology rather than of phylogeny. One of the greatest needs of biology is for more detailed and accurate information regarding them; we must know exactly what happens in each case, the physiology of the response irrespective of its usefulness, and then perhaps the latter may find an explanation. It is certainly premature to abandon hope of finding a natural and causal explanation of such phenomena, as Driesch and Wolff do, before we are really acquainted with the phenomena themselves.

Some of these contingent adaptations probably belong to the fundamental and original properties of living things and as such are not to be explained by any theory of evolution; for it must not be forgotten that organic evolution is a theory of transmutation which undertakes primarily to explain the diversity which exists

in the living world, but not the original properties of life. It undertakes to explain the various forms of adaptations found in the living world, but not protoplasmic adaptability. If life is "continuous adjustment of internal relations to external relations," as Herbert Spencer held, then life is adaptability, and it would be unreasonable to demand that any theory of organic evolution should explain the origin of this.

It may be that regulation or regeneration is one of the fundamental physiological properties of living things and that it belongs in the same category with assimilation, growth, metabolism, reproduction and irritability, properties which are found in the lowest organisms as well as the highest, and which can therefore be left out of the list of those things which evolution may reasonably be expected to explain.

On the other hand it seems possible that many contingent, individual adaptations may find a natural explanation in the further extension of the selection principle to the physiological responses of organisms and to the more elementary parts of which their bodies are composed. If to the natural selection of Darwin ("personal selection") there be added some such principles as the struggle of the parts ("histonal selection") of Roux, the "germinal selection" of Weismann and the method of "trial and error" of Jennings, many adaptations, otherwise inexplicable may find a natural explanation. Weismann's views have been frequently condemned because of their highly speculative character, but it cannot be denied that he has shown profound insight into the most fundamental problems of biology, and in many instances he has seen his speculations verified by subsequent research. In a masterly series of works Jennings has proved that the adaptations shown in the behavior of many lower organisms may be reduced to the simple principle of "trial and error," or the rejection of unfavorable motor responses; in this way aparently purposive behavior, which Binnet supposed to be due to the relatively complex "psychic life of microörganisms" has been shown to be due to a few simple motor reflexes, which are repeated indefinitely until they bring the organism into a favorable environment. Darwin himself suggested this explanation of the apparently intelligent behavior of the earthworm, and Jennings has shown

that it is applicable to the behavior of a large number of animals. This principle of "trial and error" is in reality the rejection or elimination of unfit responses during the individual life of an organism, and if a similar principle should be found to be applicable to other physiological processes it would probably explain in equally simple manner many apparently purposive responses which are at present inexplicable. Thus the simple principle of the elimination of the unfit, whether of individuals, or of parts of individuals, or of physiological responses, would offer a possible and natural explanation of the almost universal occurrence of fitness in the living world.

But whether the Darwinian theory is capable of explaining all the fitnesses of organisms or not, it does succeed, as no other theory does, in offering a natural and causal explanation of very many of these wonderful phenomena. The development of particular structures and functions to meet particular conditions of life, such as organs of locomotion, sensation, digestion and reproduction; organs and instincts of protection, offense and defense; and all the multitudes of diverse forms and ways in which organisms are fitted to carry on the fundamental properties of life amidst the most varied conditions—these diversities we may reasonably expect a theory of evolution to explain, and it is the crowning glory of Darwin's theory that it is, on the whole, able to explain them.

IV.

This is a brief review of Darwin's most important work. Some of his generalizations have been and still are of the greatest importance, others were of less value and have since been abandoned. In this respect his work is not unlike that of other scientists, and yet we all recognize that Darwin occupies a unique position in biology; that indeed he stands almost alone in the greatness of his influence on the world, and that his name can be properly associated only with that of Sir Isaac Newton, by whose side he lies in Westminster Abbey, and with two or three others in the whole history of science.

What is the secret of the tremendous influence which Darwin has had upon the entire world? He was of course a remarkable man, remarkably well prepared for a supremely great work. Keen

observer of nature in many lands, gifted with unusual ability in collecting, weighing and systematizing facts, endowed with a fertile imagination and with great powers of generalization, and yet cautious, slow in reaching conclusions, honest beyond all others, a man who worked every day of his life to the limit of his strength—none like him had ever before grappled with the mysteries of creation.

But apart from his own peculiar fitness for this work Darwin was unusually fortunate in his opportunity and his environment. The world was ready for him. Lamarck, St. Hilaire, Mendel addressed a world not ready to receive their messages. But in 1859 the need of some natural explanation of the origin of species was keenly felt and many naturalists were groping in the dark for some rational solution of this problem. In his autobiography Darwin says in explaining the success of the "Origin of Species":

> What I believe is strictly true is that innumerable well-observed facts were stored in the minds of naturalists ready to take their proper places as soon as any theory which would receive them was sufficiently explained.

The problem itself was one of the greatest which had ever been raised in the history of science. Step by step miraculous intervention in nature had been eliminated and supernaturalism had been driven from astronomy and geology and embryology and had taken its last great stand on the special creation of species and the supernatural origin of adaptations. To many people evolution seemed to be an atheistic attempt "to drive God entirely out of his universe." It presumed to determine man's place in nature, and many believed that if man were descended from the beasts which perish he could not be a son of God. It has been said that there are two subjects in which all people are interested—theology and politics. Evolution certainly caused a disturbance in theology and it accordingly came as a shock to all Christendom. The necessity of defending it before the public converted scientists into controversialists, and probably no scientific theory before or since ever received so much popular attention.

Again Darwin owed very much to his friends, especially to Lyell, Hooker, Huxley and Asa Gray. The idea of fighting for his theory seems to have come to him only gradually after the first shock of the

brutal assaults upon it. Six months after the publication of the "Origin" he wrote to Hooker:

> I look at their attacks as proof that our work is worth the doing. It makes me resolve to buckle on my armor. I see plainly that it will be a long uphill fight. But think of Lyell's progress with geology. One thing I see most plainly, that without Lyell's, yours, Huxley's and Carpenter's aid, my book would have been a mere flash in the pan. But if we all stick to it we shall surely gain the day. And I now see that the battle is worth fighting.

Many a discovery, like that of Mendel, is launched meekly and modestly into the world, to sink to oblivion or to be lost from sight, only to be rediscovered at some future time. Not so with a militant truth; it challenges and demands attention, and in the case of Darwin's theory it richly deserved it.

Next to his friends Darwin owed most to his enemies; the attacks upon him and his theory were so violent, so brutal, so out of reason, that his own sane, calm and absolutely honest course shone with all the more luster. To these unreasonable attacks and to the same reaction which was bound to follow, Darwin, as well as his great contemporary Lincoln, owed very much.

But wholly apart from these circumstances which contributed only temporarily to his reputation and influence, Darwin stands as one of the leaders of science for the great work which he did; work of lasting value which has not yet been outgrown and which can never be forgotten. He stands as a leader in science because of the methods of his work; he was so broad and science has since become so specialized that we can never hope to see his like again; he was so honest in dealing with objections to his theories and so sane in judgment that he was never carried away by his own enthusiasm; above all he was so patient in his work that his example may be especially commended to this impatient age; on every one of his principal works he spent from five to twenty years of the hardest labor of which he was capable, and it is not to be wondered at that this work has lasting value. Charles Darwin stands today and will continue to stand for years to come as one of the most impressive and influential figures in human history.

Mr. President: I beg leave to introduce the following minute:

On this hundredth anniversary of the birth of Charles Darwin,

the American Philosophical Society, in common with learned societies throughout the world, desires to record its high appreciation of this illustrious man and of his inestimable services to science and to the entire intellectual world; it recalls with satisfaction that he was for thirteen years before his death a member of this society, having been elected in 1869; that his grandfather, Erasmus Darwin, was also a member; that his son, Sir George Darwin, is a member of this society, and that on the occasion of the bicentennial celebration of the birth of Franklin, our founder, he was present as the bearer of fraternal greetings from the University of Cambridge, the Royal Society, the Royal Institution of Great Britain, and the British Association for the Advancement of Science; and that by his scientific addresses on that occasion, as well as by his presentation of Medalions of Erasmus Darwin and Josiah Wedgwood, grandfathers of Charles Darwin, he strengthened the bonds which connect the American Philosophical Society with the immortal name of Darwin.

PRINCETON UNIVERSITY.